US006241921B1

(12) **United States Patent**
Jacobson et al.

(10) **Patent No.: US 6,241,921 B1**
(45) **Date of Patent: Jun. 5, 2001**

(54) **HETEROGENEOUS DISPLAY ELEMENTS AND METHODS FOR THEIR FABRICATION**

(75) Inventors: **Joseph M. Jacobson**, Newton; **Hidekazu Yoshizawa**, Brookline, both of MA (US)

(73) Assignee: **Massachusetts Institute of Technology**, Cambridge, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/206,310**

(22) Filed: **Dec. 7, 1998**

Related U.S. Application Data

(60) Provisional application No. 60/085,578, filed on May 15, 1998.

(51) **Int. Cl.**[7] **B29D 11/00**

(52) **U.S. Cl.** **264/1.36**; 264/1.7; 264/437; 264/438; 264/4.1

(58) **Field of Search** 264/1.1, 1.36, 264/1.38, 1.7, 108, 343, 436, 437, 439, 440, 4, 4.1, 438, 484, 491

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,800,457	7/1957	Green et al.	252/316
3,406,363	10/1968	Tate	335/302

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

19529264A1	2/1996	(DE) .
0 622 721 A1	11/1994	(EP) .
2292119A	2/1996	(EP) .
2324273A	10/1998	(EP) .
2077148A	12/1981	(GB) .
01177517	7/1989	(JP) .
WO94/28202	12/1994	(WO) .
WO 97/04398	2/1997	(WO) .
WO 98/03896	1/1998	(WO) .

OTHER PUBLICATIONS

Jin, S., et al., "Optically Transparent, Electrically Conductive Composite Medium," Science, pp. 446–448 (Jan. 1992).
Yang, Y., et al., "A New Architecture for Polymer Transistors," Nature, vol. 373 (Nov. 1994).
Egashira, N., et al., "A Solid Electrochromic Cell Consisting of Lu–Diphthalocyanine and Lead Fluoride," Proceedings of the S.I.D., vol. 28/3, pp. 227–232 (1987).
Chen et al., "Interfacial Phenomena Controlling Particle Morphology of Composite Lataxes," *J. App. Pol. Sci.*, vol. 42, pp. 1049–1063 (1991).

(List continued on next page.)

Primary Examiner—Mathieu D. Vargot
(74) *Attorney, Agent, or Firm*—Testa, Hurwitz & Thibeault LLP

(57) **ABSTRACT**

Optically heterogeneous display elements utilize fused pigment particles, which may be manufactured with polymer shells having desired charge, photoresponse, or density characteristics. The particles may be microencapsulated prior to formation of the display element, so that the element is formed internally within the container in which it is permanently housed. The element may function as a bichromal display, a light valve, or a programmable magnetic element.

11 Claims, 10 Drawing Sheets